

Comparing the Performance Attributes of Photocatalytic and Hydrophilic Glass Products



The latest innovations in glass technology are “self-cleaning” and “low-maintenance” window glass, two categories which encompass window glass products that are coated or fused with titanium dioxide (TiO₂) alone or with underlayers or silicon dioxide (SiO₂).

Each of the four largest glass suppliers to the United States markets a self-cleaning or low-maintenance glass product. The companies, the brand names and the coating formulations they use on their self-cleaning products are specified in the

chart below. TiO₂ is the active coating for *SunClean*[®] Glass by PPG, *Activ*[™] Glass by Pilkington and *Radiance Ti*[™] Glass by AFG. *LoE⁺ Plus* Glass by Cardinal has a functional coating of silicon dioxide.

Product Name	Manufacturer	Active Coating
<i>SunClean</i> [®] Glass	PPG Industries	TiO ₂
<i>Activ</i> [™] Glass	Pilkington plc	TiO ₂
<i>Radiance Ti</i> [™] Glass	AFG Industries	TiO ₂
<i>LoE⁺ Plus</i> [™] Glass	Cardinal Glass Industries	SiO ₂

Characteristics of Self-Cleaning Glass

The AIA MasterSpec identifies Pyrolytic-Coated Self-Cleaning Low-Maintenance Glass as follows: *Float glass with a coating on the first surface having both photocatalytic and hydrophilic properties that act to loosen dirt and to cause water to sheet evenly over the glass instead of beading.*

Products marketed by their manufacturers as self-cleaning should possess *all* of the following characteristics, while those identified as “low-maintenance” may feature only one of the following characteristics:

Hydrophilicity — This term describes the property of a surface that makes it have an affinity for water. When water hits hydrophilic glass, it flattens and spreads out to form a thin sheet on the glass surface. This sheeting action not only helps rinse away loosened dirt and other organic material. The sheeting action also minimizes spots and streaks by helping the glass dry more quickly and evenly.

Photocatalysis — This term describes the property of a surface which allows it to decompose organic material. On a self-cleaning window, the surface of the glass will help break down loose dirt and other organic material. This allows the sheeting action of the water to more easily rinse loosened dirt away. This property also helps the glass maintain its hydrophilicity (ability to sheet water). Products lacking a photocatalytic component can quickly lose their hydrophilic properties.

Durability — This property describes a self-cleaning glass’ ability to maintain its coating over time. Some products marketed as low-maintenance glass employ coatings that are not fused to the glass surface. These products can quickly lose their hydrophilic properties.

Other products feature *hydrophobic* coatings, which repel water, causing it to bead rather than sheet. This makes the glass more susceptible to water spotting than products manufactured with *hydrophilic* coatings.

The most durable self-cleaning products are those with active coatings *fused* to the surface of the glass at extremely high-temperatures through chemical vapor disposition (CVD) technology. But even among the CVD products, there is a range of durability. Only the following products use CVD technology:

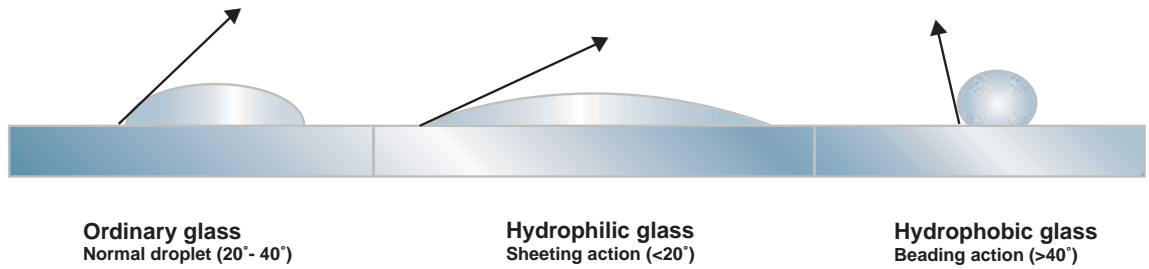
- *SunClean*[®] Glass (PPG)
- *Activ*[™] Glass (Pilkington)
- *Radiance Ti*[™] Glass (AFG)

Comparing Performance

Recently, a major U.S. glass manufacturer commissioned an independent study to compare the performance characteristics of self-cleaning and low-maintenance glass products according to the three major criteria outlined above.

1. Hydrophilicity

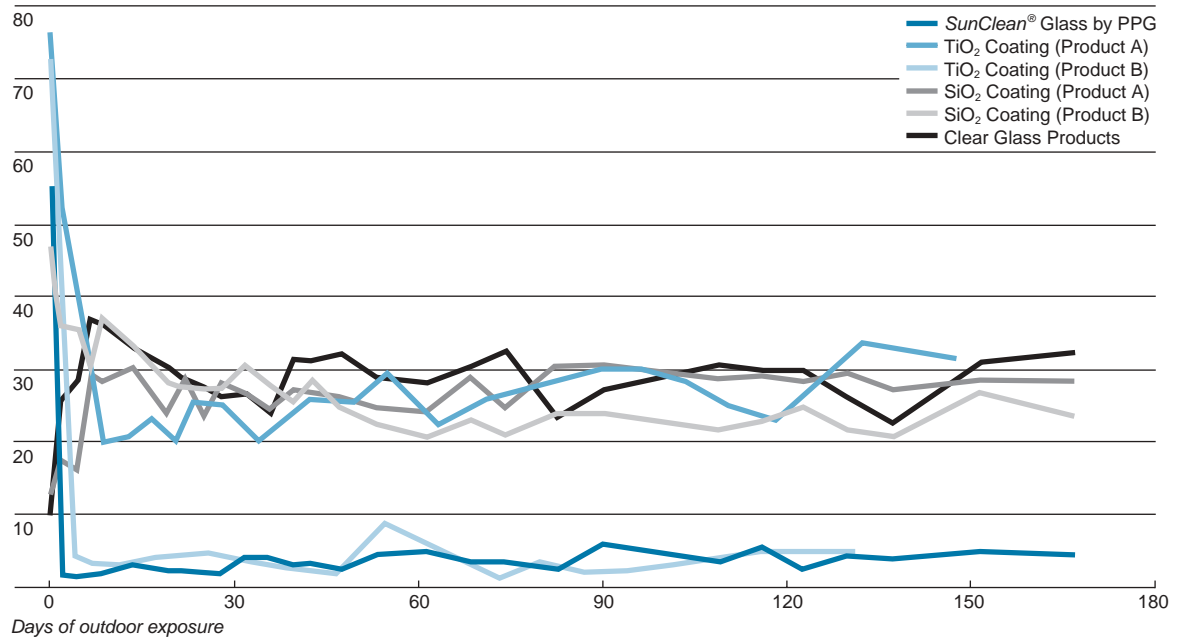
A glass surface is considered to be *hydrophilic* if the contact angle of a water bead on its surface is less than 20 degrees. In contrast, a *hydrophobic* surface (which promotes beading like that of a freshly waxed automobile) has a contact angle of more than 60 degrees. The contact angle on ordinary glass measures 20-40 degrees (*see illustration*).



Coating Structure Compositions

Hydrophilic Properties

Contact angle of water (deg)



The chart above demonstrates the hydrophilic properties of each of the four self-cleaning products compared to clear glass by measuring their

contact angles after outdoor exposure to UV rays. (UV rays are required to activate the hydrophilic properties of TiO₂ coatings.)

Two products formulated with titanium dioxide (TiO₂) coatings — *SunClean* Glass and *Activ* Glass — clearly maintain their hydrophilic properties longer than *LoE² Plus* Glass by Cardinal Glass, whose silicon dioxide (SiO₂) coating quickly loses its ability to sheet water.

Radiance Ti Glass, which uses TiO₂ as the active coating, loses its hydrophilic properties rapidly with outdoor exposure. This indicates that this particular TiO₂ coating is not effective enough to help maintain hydrophilicity.

Summary: Test results show that *SunClean Glass* and *Activ Glass* maintain their hydrophilic properties longer than competing products.

2. Durability

The durability of self-cleaning glasses was measured in this testing according to three distinct criteria (Low-maintenance glasses were not tested because their coatings are not detectable.):

- Outdoor Durability
- Chemical Durability
- Mechanical Durability

Outdoor Durability

This performance characteristic was measured by gauging visible color changes in reflection using MacAdam Units, a universally recognized standard employed in color-matching systems. Color changes of 4.0 MacAdam Units or greater are visible to the naked eye and indicate that the coating has degraded due to the debilitation of its chemical composition or the removal of some or all of the coating.

The following chart shows the average color change of *SunClean* Glass (PPG) and *Activ* Glass (Pilkington) — the two best performing self-cleaning glasses — in three distinct U.S. locales. Changes were measured over 17 months.

Outdoor Durability Vertical Exposure (~4-2002 to 11-2003)

ΔE (MacAdam Units)

- *SunClean*® Glass 5-6 mo
- *Activ*™ Glass 5-6 mo
- *SunClean*® Glass 13-17 mo
- *Activ*™ Glass 13-17 mo

Pittsburgh, PA



Ft. Lauderdale, FL



Phoenix, AZ



0 1 2

Summary: *SunClean Glass* maintains its coating integrity in a range of common environmental conditions more effectively than the next best competitor.

Chemical Durability

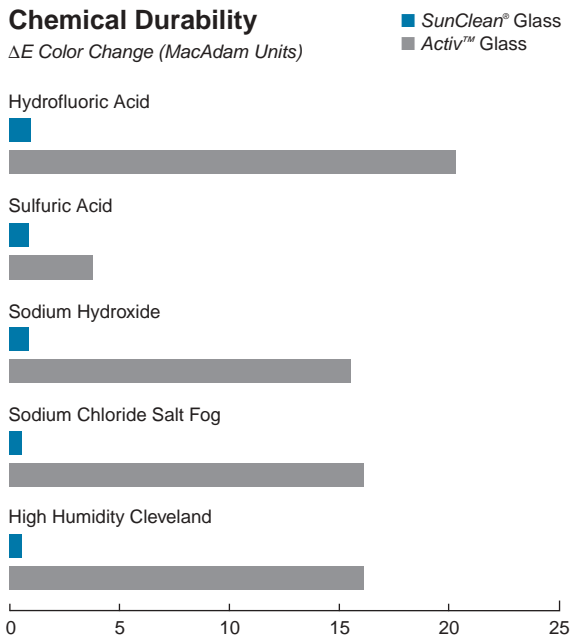
To measure chemical durability, the two best-performing self-cleaning glass products — *SunClean* Glass (PPG) and *Activ* Glass (Pilkington) — were subject to accelerated weathering exposure and harsh chemicals, including:

- Hydrofluoric acid
- Sulfuric acid
- Sodium hydroxide
- Sodium chloride salt fog
- High humidity (Cleveland Condensation Chamber)

As with the *Outdoor Durability* study cited above, each glass' ability to withstand the corrosive effects of these conditions was measured by their ability to maintain coating integrity. Again, any reflective color change measuring 4.0 MacAdam Units or more indicates a degradation of the coating, resulting in color changes that are visible to the naked eye.

Chemical Durability

ΔE Color Change (MacAdam Units)



Among the two top-performing self-cleaning glasses — *SunClean* Glass and *Activ* Glass — only *SunClean* Glass experienced MacAdam Unit changes of less than 4.0 Units in all five tests. *Activ* Glass maintained chemical stability when exposed to sulfuric acid, but failed in the four other tests. However, even in this test, *SunClean* Glass significantly outperformed *Activ* Glass.

Summary: *SunClean* Glass is the only self-cleaning glass to maintain chemical durability when exposed to a variety of accelerated weathering and harsh chemical conditions.



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Mechanical Durability

SunClean glass coating has consistently demonstrated exceptional coating durability during customer trials for handling, packaging and shipping practices for insulated glass and window sash unit fabrication using Low-E best practices, the industry standard for fabrication of coated glass products.

To demonstrate *SunClean* glass' ability to withstand these unit fabrication tests, the glass was processed coating side *down* for these trials. *SunClean* glass maintained its coating integrity through the following processes:

- Glass storage
- Glass cutting (drop table)
- Harp rack
- Seaming
- Tempering line washer
- Tempering furnace
- Insulating glass line washer
- Insulating glass line assembly

In addition, in independent, proprietary mechanical durability tests of TiO₂-only coatings, *SunClean* glass by PPG demonstrated measurably better coating integrity than *Activ* glass by Pilkington.

Final Summary

SunClean Glass demonstrated superior results in testing for hydrophilicity, photocatalysis and durability.

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Hydrophilic Properties

Contact angle of water (deg)

